

Public Health Sector: The EpiSims Module

The National Infrastructure Simulation and Analysis Center (NISAC) provides advanced modeling and simulation capabilities for the analysis of critical infrastructures and their interdependencies, vulnerabilities, and complexities. These capabilities help improve the robustness of our nation's critical infrastructures by aiding decision makers in the areas of policy analysis, investment and mitigation planning, education and training, and near real-time assistance to crisis response organizations.

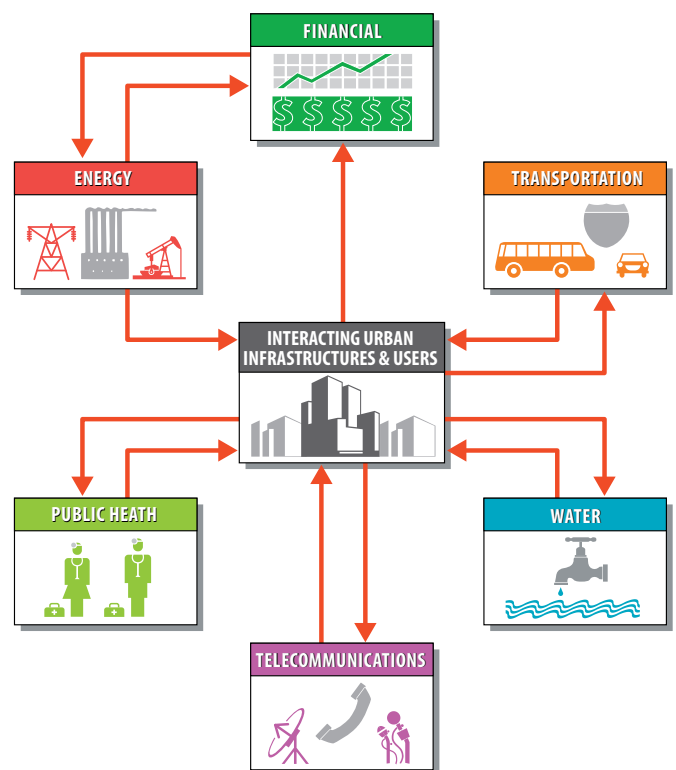
The Department of Homeland Security's (DHS) Information Analysis and Infrastructure Protection (IAIP) Directorate sponsors the NISAC program. NISAC is a core partnership of Sandia National Laboratories (SNL) and Los Alamos National Laboratory (LANL). NISAC integrates the two laboratories' existing expertise in modeling and simulation to address the nation's potential vulnerabilities and the consequences of disruption among our critical infrastructures.

The Urban Infrastructure Suite (UIS) is a set of seven interoperable modules that employ advanced modeling and simulation methodologies to represent urban infrastructures and populations. (See figure.) These simulation-based modules are linked to model urban transportation, telecommunications, public health, energy, financial (commodity markets), and water-distribution infrastructures and their interdependencies.

The Epidemiological Simulation Systems (EpiSims) Module simulates the spread of disease in urban areas. It details the demographic and geographic distributions of disease and provides decision makers with information about (1) the consequences of a biological attack, (2) the resulting demand for health services, and (3) the feasibility and effectiveness of response options.

EpiSims creates a social network representing details of contacts between individuals based on their activity patterns, which are provided by the UIS Urban Population Mobility Simulation Technologies (UPMoST) and Transportation Analysis Simulation System (TRANSIMS) modules, as shown in the figure below.

EpiSims combines social-network information with assumptions about the progression of disease within a host and the transmission between hosts. The result is a detailed estimate of how disease will spread from



The relationships between EpiSims (in lime green) and the other UIS modules.

person to person through a population by taking into account the activities and contacts of each person.

Key Features

EpiSims provides estimates of how disease will spread through a population depending on how the disease is introduced, how vulnerable people are, what responses are applied, and when the responses are applied.

The EpiSims module simulates the movement of each individual from location to location in a large urban area as he or she goes about daily activities. The individuals are synthetic—they do not represent actual people—but a census taken on the entire synthetic population would be statistically identical to the actual census. On the other hand, the locations visited by individuals are real street addresses and reflect actual land-use patterns in the city.

EpiSims associates a state of health with each individual being simulated. An individual's demographics determine his or her response to exposure and infection. For example, anyone over the age of 32 is assumed to have been vaccinated for smallpox. Exposure occurs either through contact with an infectious person or by visiting a contaminated location. The simulation user can introduce contamination at a location as an exogenous

event. Whether a person is infectious depends on when that person was exposed and his or her individual response to infection. By varying a few parameters, users can model many different diseases.

A simulated person's state of health can affect his or her actions. The person can seek treatment at a nearby hospital or clinic or stay home instead of pursuing certain activities. In addition, the simulation user can specify actions that affect simulated people, such as mass or targeted vaccination/treatment/prophylaxis and isolation. Targeted responses are automated within the simulations: people are chosen at a user-specified rate from a list of symptomatic people; their contacts are found by following their schedules; and the contacts are then treated and/or isolated.

EpiSims' architecture allows the module to handle large volumes of data that may represent a metropolitan area in detail. The software is integrated more tightly with the UIS framework code, which is specifically designed to handle large data sets.

EpiSims' parallel-execution capability has been tested on computing clusters with up to 1000 processors.

EpiSims is easy to use, permitting various disease models to be easily tested and compared with EpiSims' output.

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